

## Short Communication

## Kinetic Characteristics, Phase and Structural Changes in Electrical Materials and Devices

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Electron-microscopic and X-ray studies have revealed that the ability of lead-acid storage batteries to adopt charge due to physico-chemical processes occurring in the lead paste and on the border of the “shunt-paste” depends dramatically on both the initial moisture content in the lead paste and keeping enhanced humidity in the exposure chamber for plates.

**Keywords:** Scanning electron microscopy, X-ray diffraction, Lead-acid batteries

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## 1. INTRODUCTION

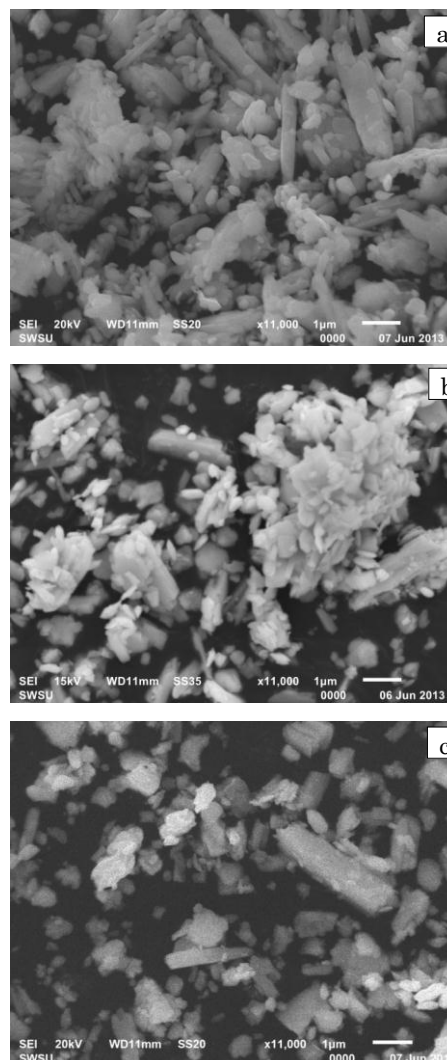
Chemical composition, phase structure of both electrode composition and active material influence greatly service properties of lead-acid storage battery along with operating practice of formation [1]. Despite a long history of using these power sources the consistent analysis of the interrelation of the triad “composition-structure-properties” has not been made. In the paper, in development of earlier investigations on this problem [2], structural and phase changes that accompany the surface formation and charge formation on electrode plates and their influence on functional and electric characteristics of storage batteries have been studied by electron microscopic (SEM) (JEOL JSM6610LV) and X-ray techniques (X-ray study) (GBC EMMA, CuK $\alpha$ ).

## 2. EXPERIMENTAL SECTION

Samples of lead mass were prepared according to the standard procedure from highly-oxidized lead powder – PbO ( $76 \pm 1$  %) and sulfuric acid solution of  $1.4 \text{ g/cm}^3$  with mass ratio of compositions: 4.9 for positive and 4.5 % for negative sample. The negative active mass included 1 % carbon, barium sulphate and stretcher Vanisperse HT-1. Dried electrode plates were used to assemble storage batteries of rated capacity 60 A·h. The electrodes were manufactured by stamping and stretching method from Pb-Ca-Sn melt. Studied were three groups of electrode plates produced in several stages in a soaking chamber with humidity that was prepared by various ways:

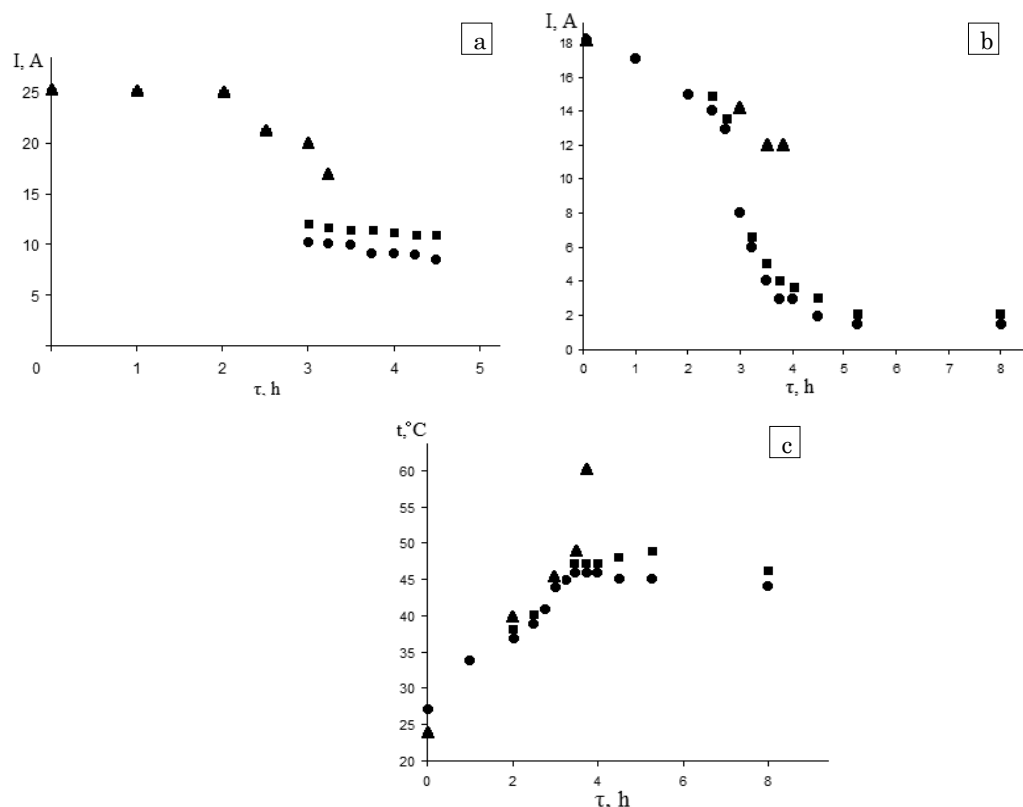
- by steam generator – immediately after manufacturing with exposure during 22 h at a temperature of  $45 \pm 5$  °C and a relative humidity of 95-65 % and with consecutive drying during 14 h at a temperature of  $65 \pm 5$  °C and a relative humidity of 5-10 %;
- by wetting the floor with water before loading plates and spraying water with injectors – at analogous modes.

Studied were also electrode plates exposed during 2 h at a temperature of  $25 \pm 1$  °C and a relative humidity of  $80 \pm 2$  %.



**Fig. 1** – Paste structure of negative electrode plates after exposure and drying: a – the first group, b – the second group, c – the third group





**Fig. 6** – Kinetics of current changes in samples of various groups: (●●●) – the first group, (■■■) – the second group, (▲▲▲) – the third group; ( $25 \pm 1^\circ\text{C}$  without cooling, 16 V at batteries charging); a –  $I_{\max} = 25$  A; b –  $I_{\max} = 18$  A; c – temperature changes as for b-case

obviously due to significant inhomogeneity of the surface structure (Compare Fig. 4a and Fig. 4b).

The fact that the capacity of the third group's batteries was constant is indicative of a low activity of the charge-forming electrode surface.

Charging capacity of batteries was checked when these charged at a constant voltage of 16 V after 20-h discharging. In the samples of the first group the electrodes have the lowest transitional resistance of "shunt-active mass" and hence, electric energy losses to overcome internal resistance were minimal.

The distinction among internal resistances was established by studying the kinetics of decreasing resistance (Fig. 6a, b), which is also supported by an abrupt increase in electrolyte temperature for samples of the third group. Two hours of discharging the current

value remained constant and was equal to 25 A; electrolyte temperature of the samples of the first and second group amounted to  $40^\circ\text{C}$ , while of the third group's samples amounted to  $45^\circ\text{C}$ , which is obviously due to dramatically higher resistance.

#### 4. CONCLUSIONS

Thus, functional and electric characteristics of storage batteries critically depend on physico-chemical processes occurring within the lead paste and on the border of the "shunt-paste", which are most dependent on both the initial moisture content in the lead paste and keeping enhanced humidity in the exposure chamber for plates.

#### REFERENCES

1. D. Pavlov, *Lead-Acid Batteries Science and Technology* (Elsevier science: 2011).
2. A.P. Kuzmenko, A.V. Stepanov, V.F. Niyazi, A.M. Ivanov, E.A. Grechushnikov, V. Kharseev, *Proceedings of Southwest State University. Physics-Chemistry* 41, 2 (2012).